

THE LINDE GROUP

Linde

Freezing to perfection.

With CRYOFLEX[®]
freezers from Linde.



On the way to perfection.



Sub-zero treatment

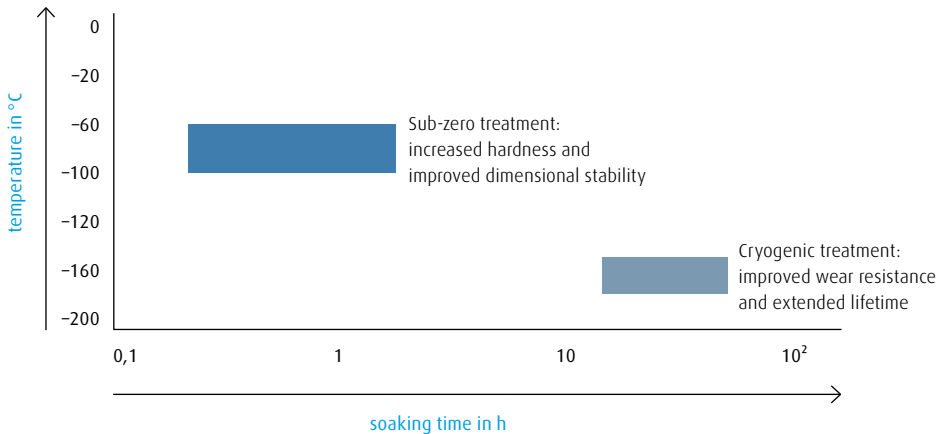
Many manufacturers in industries such as automotive, aviation, aerospace and machine tooling rely on heat treatment processes to improve material properties. In the constant search to optimise heat treatment results, more and more players are focusing on sub-zero treatment – a cryogenic step that follows a normal heat treatment process.

By transforming retained austenite into martensite and by precipitating fine-carbides, sub-zero-treatment delivers the following key benefits:

- Improved hardness
- Dimensional stability
- Increased wear resistance
- Extended part lifetime

On the following pages you can learn more about the physics behind sub-zero treatment, how our CRYOFLEX® family can meet all your sub-zero treatment needs and why Linde is the partner of choice for this application technology.

Parameter of sub-zero and cryogenic treatments



The physics in a nutshell

Increased wear resistance and part lifetime

Wear resistance and the lifetime of high-alloy and tool steels can be significantly increased through the correct application of sub-zero treatments.

Beside the well-known benefits coming from sub-zero treatment, Linde offers solutions for cryogenic treatment as well. These cryogenic treatments are typically performed in the temperature range from -150 to -180 °C and take 24 to 72 hours (see illustration above). Beyond the transformation of retained austenite to martensite, cryogenic treatment has the added effect of precipitating fine carbides in the steel microstructure. This improves wear resistance and extends service life even further.

Increased hardness and improved dimensional stability

At room temperature, retained austenite is unstable and will slowly transform over time. This transformation can cause dimensional changes, resulting from rearrangement of the crystallographic structure.

Components that require a high degree of precision must be engineered to avoid this uncontrolled transformation. This can typically be achieved with a sub-zero treatment in the temperature range from -60 to -100 °C over a period of 1-2 hours (see illustration above). This cold treatment not only improves dimensional stability but also increases hardness. The increase in hardness is attributable to the transformation of the steel microstructure from austenite to martensite, which is stronger and harder.



Loading of a CRYOFLEX cabinet

Creating value

Investments in professional sub-zero application technologies generally pay rapid dividends. Here liquid nitrogen is the cooling agent of choice as it enables temperatures down to -180°C , and accelerates cycle times.

We deliver a range of sub-zero solutions designed to the highest standards of quality and safety. They also come with leading features enabling fully automatic temperature tracking and reporting capabilities that comply with the rigorous demands of the aerospace industry, for instance.

CRYOFLEX family with best-in-class features

All of our CRYOFLEX products are designed for ease of operation, maximum safety and cost efficiency.

CRYOFLEX B and C cooling equipment come with the following feature set as standard:

- Controlled cooling down to -150°C
- Cooling rate adjustable to parts dimension
- An additional product thermocouple monitors the part's temperature. This data is used to start the soaking time and to ensure a proper temperature profile without any overshooting.

Advanced safety:

- Automatic safety system disconnecting liquid nitrogen (LIN) supply if the door is inadvertently opened during the process cycle
- Second valve that disconnects the LIN supply if the first valve fails
- Optical warning signals
- Option to connect atmosphere controller for the surrounding environment

State-of-the-art technologies:

- PLC controller
- User-friendly control program
- Robust stainless steel design for extended lifetime
- Ease of installation and relocation

CRYOFLEX also comes with the following optional extras:

- Tempering option (heating up to 300 °C)
- Drying option (heating up to 60 °C) to avoid humidity condensation on the treated parts
- Gaseous nitrogen purging to prevent from moisture
- Cooling down to -180 °C
- Guillotine door (CRYOFLEX C)
- **New:** Temperature tracking and reporting as well as certified thermocouples to conform with aviation, aerospace and automotive requirements (AMS 2750E/CQI-9)



The perfect fit for your individual application challenge.

You can choose from our three off-the-shelf CRYOFLEX freezers – our cabinet, box and continuous models. Complementing this standard offering, we also design customised models and sizes for your specific needs.



CRYOFLEX C – cabinet freezer

Adopted to standard heat treatment batch dimensions to ease the handling from furnaces to CRYOFLEX equipment. Our cabinet freezers are built for convenient front loading with fork lifts for example. Depending on the size, it comes with up to 3 fans inside the chamber to ensure maximum temperature uniformity and fast cooling.

Temperature range: room temperature to -150°C .



CRYOFLEX T – tunnel freezer

For continuous processes, we have developed a special tunnel freezer solution, which is installed in front of the tempering unit. Supporting line speeds of 0.07–0.33 m/min, it is the ideal way to cool small parts with a maximum height up to 125 mm.

Temperature range: room temperature to -100°C .



CRYOFLEX B – box freezer

This box freezer is designed for relatively low production volumes and small parts. It comes in different sizes to suit individual requirements (80–600 l). Specially designed liquid nitrogen injection systems located on the side of the fan circulate the cooling medium, ensuring optimum performance and efficiency. The pneumatic door ensures easy loading of the freezer.

Temperature range: room temperature to -150°C .



CRYOFLEX CC – metal strip contact cooling

To cool down moving blade strips more effectively, we developed a continuous contact cooling solution. Up to eight strips can be cooled in parallel and the total length of CRYOFLEX CC can be adapted to the feed rate of the overall line.

Temperature range: room temperature to $-160\text{ }^{\circ}\text{C}$ (cooling plate).

Linde – your ideal partner for sub-zero treatments.

Experience counts

We have long-standing experience in sub-zero treatments, having successfully implemented more than 100 cryogenic freezers around the world. Here we also build on our vast experience in food freezing, where we have been a leading global player for decades.

Deep process know-how

Our team of experts has vast experience in configuring and installing solutions of all models and sizes and can help you customise your system to solve your individual production challenges. Our expertise ranges from heat treatment through freezer engineering to control systems and tailored gas supply concepts.

Supply and supporting services

We will work with you to calculate the volume of liquid nitrogen you require and size your tank and piping accordingly. With Linde, you can rely not only on the highest reliability and safety standards, you can also benefit from our complementary gas management services, including automated tank level monitoring to simplify ordering, and internet-based cylinder and tank tracking to give you an instant overview of your gas assets.

Let's discuss how we can help you.



Linde AG

Gases Division, Carl-von-Linde-Strasse 25, 85716 Unterschleissheim, Germany
Phone +49 89 31001-0, info-heattreatment@linde.com, www.linde-gas.com/heattreatment

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